THE POSITION OF THE PALEOGENE FORMATIONS OF HUNGARY IN THE STANDARD NANNOPLANKTON ZONATION

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Abstract

This paper gives a comprehensive review of the nannoplankton stratigraphy in the Paleogene formations of Hungary. Each formation is shortly characterized, followed by the description of the nannofloras. Other important fossils and the basic biozones are mentioned, too. A list of references makes the descriptions complete.

The Paleogene formations of Hungary reach from the Middle Eocene until the top of the Oligocene. The earliest nannoplankton datum published so far is NP 14, Lutetian while the youngest one is NP 25, Egerian (Chattian).

Introduction

The publishing of this paper is motivated by the ascending curve of the development of nannoplankton stratigraphy in the last 30 years. The determination of the geological age using calcareous nannoplankton became one of the most widespread methods of paleontology. At the same way, this is probably the cheapest way too, demanding very few material and technical apparatus to the examinations. This method can be used first of all in the Cenozoic sediments of the oceanic and epicontinental realm. Its remarkable accuracy in the correlation with the radiometrical and magnetostratigraphical scales gives a prominent importance to the nannoplankton investigations not only among the experts of stratigraphy. The method is often used by other experts – sedimentologists, geophysicists, experts of tectonics – too.

The development mentioned above influenced also the research in Hungary, thus the bulk of the Tertiary formations has been dated with the help of the Standard Nannoplankton Zonation by the eighties of this century. This work has been more or less finished for the Paleogene formations, while a great part of the Neogene formations can be regarded as "terra incognita" from the point of view of nannoplankton. Of course the nannoplankton stratigraphy has yet a lot of to do in the field of refined and detailed stratigraphy, in Hungary.

We applied uniformly the Standard Nannoplankton Zonation of MARTINI (1971) to date the formations. This system was elaborated mainly for the epicontinental seas (this is fitting better to the paleogeography of the Pannonian realm, but we took into consideration the zone-defining-

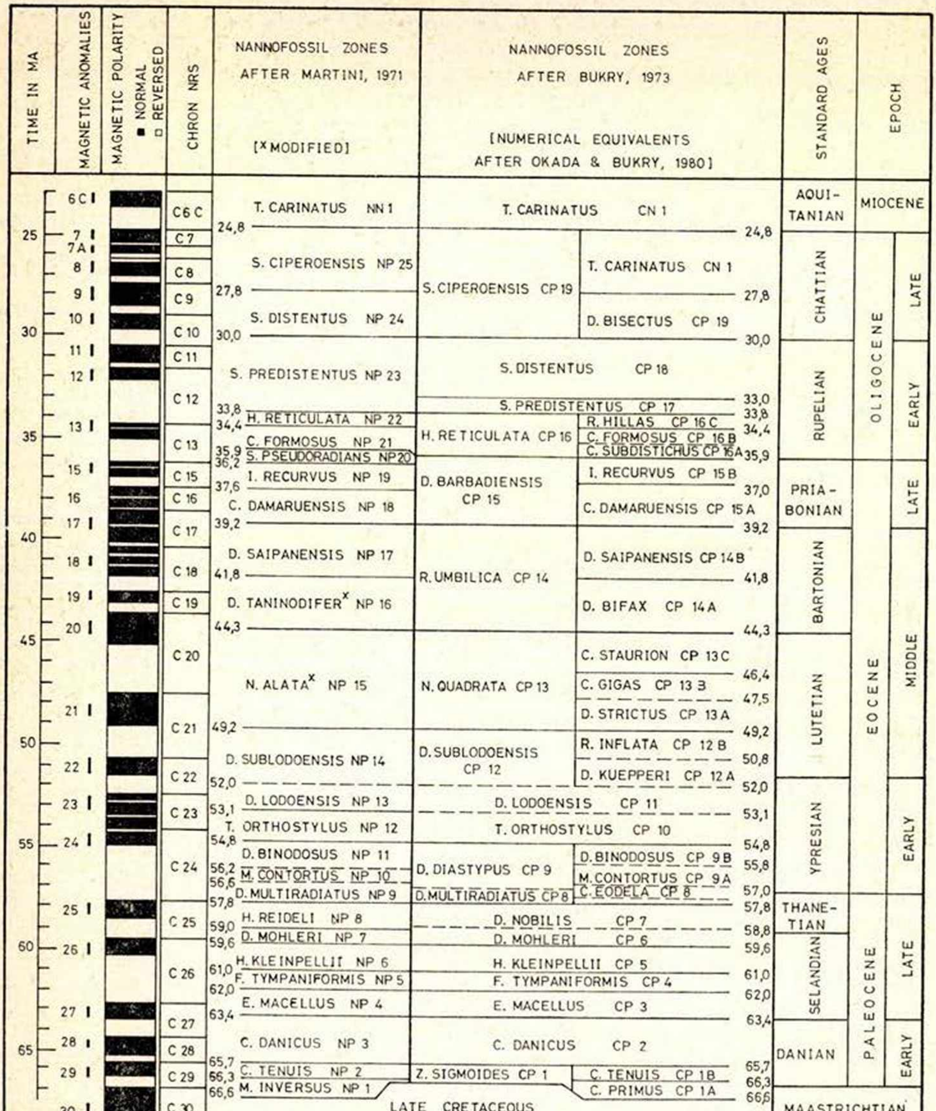

Fig. 1. Standard Nannoplankton Zonations for Paleogene (after HAQ, 1983).

events from the zonation of Okada and Bukry (1980) too, which was based first of all on the evolution of the nannoplankton in the oceans. The correlation of the two zonations is given in the figures 1 and 2. The stratigraphical position of the formations in the Standard Nannoplankton Zonations is shown in figure 3, together with the position of the stratotypes of some important Paleogene stages.

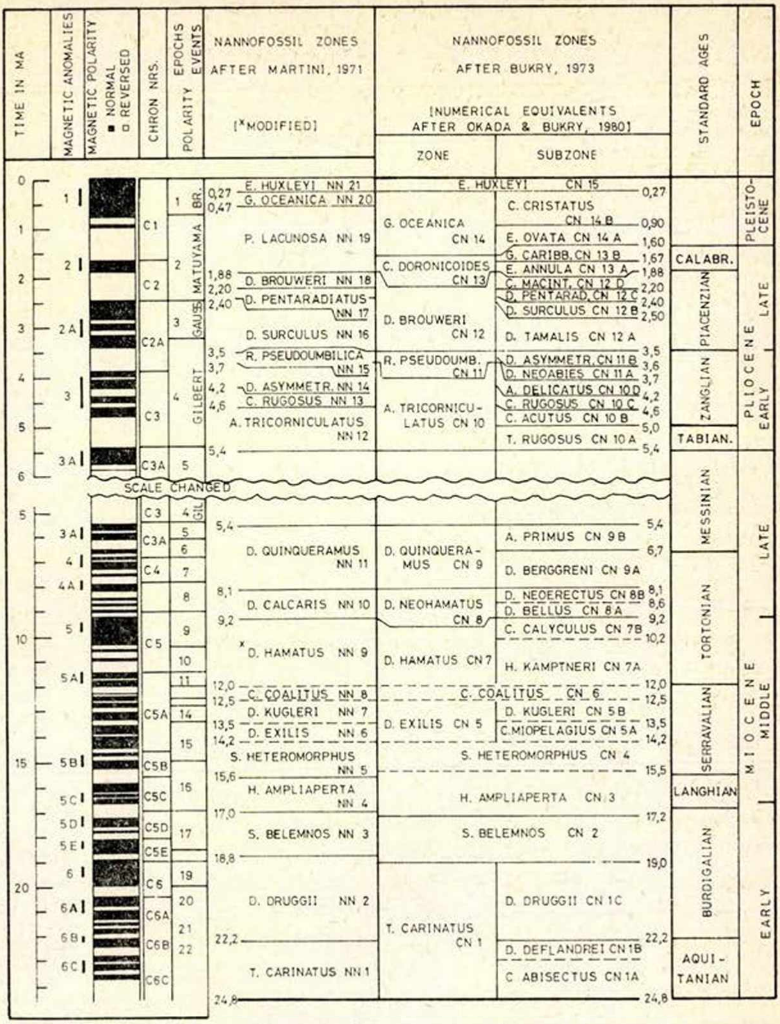

Fig. 2. Standard Nannoplankton Zonations for Neogene (after HAQ, 1983).

At the review of the formations we give a short description of their petrographical character and their areal occurence. After this, the most important nannoplankton species are listed and so the other important and characteristic fossils. Under the title "Biozonation" not only the determined nannoplankton zones will be reviewed, but also the biozones based on other fossil-groups. At the end of the description of the formation we give the references for the titles of the Lexique Stratigraphique International (L. S. I.), which contains the detailed description of the respective formations and also a detailed reference list. Discussing the Oligocene formations,

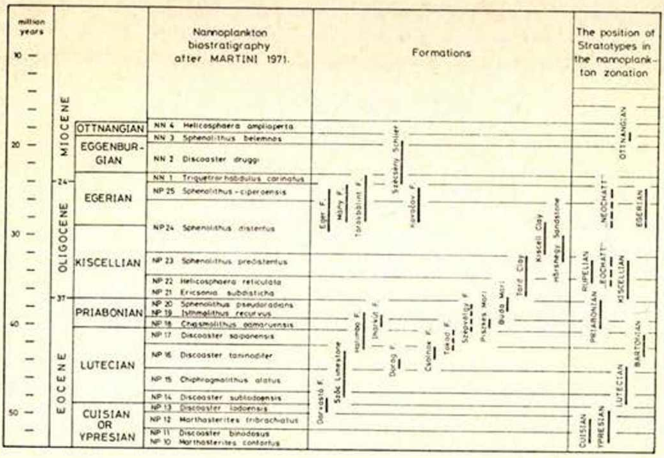

Fig. 3. The stratigraphic position of some formations of Hungary and some Paleogene stratotypes in the Standard Nannoplankton Zonation.

references are given to the modern, comprehensive monography of BÁLDI published in Hungarian (1983) and English (1986). The distribution of the Paleogene formations of Hungary in time and space is shown in the figures 4 and 5, which were compiled by the consideration of the report of the Hungarian National Committee of Stratigraphy, in 1985.

Eocene Formations

1. Darvastó Formation

The oldest, transgressional clastic sedimentary series in Transdanubia is the Darvastó Formation. It occurs only in the Southwestern Bakony, in a thickness of 25 meters (DUDICH 1977, DUDICH and GIDAI 1980, KECSKEMÉTI and VÖRÖS 1975, RÁKOSI and TÓTH 1980).

Nannoplankton: generally poor, the autochton forms are mixed with reworked Cretaceous forms. *Discoaster lodoensis* was identified in the Darvastó type section by BÁLDI—BEKE (1971). In borehole sections BROKÉS (1978) found *Discoaster sublodoensis* and *Rhabdosphaera inflata*, too. Controlling the three zone markers in a number of sections, they occur in some boreholes together, while in others one or two of them are missing (BÁLDI—BEKE 1983, 1984). The formation was placed within the zone NP 14, based on the overlapping ranges of the above mentioned three species.

Other fossils: palynomorphs (RÁKOSI and TÓTH 1980), larger foraminifera: KOPEK, KECSKEMÉTI and DUDICH (1965). JÁMBOR—KNESS (1981) placed the formation within the Cuisian by *Alveolina oblonga* and *A. rütimeyeri*. KECSKEMÉTI and VÖRÖS (1975) by a new revision found *Alveolina stipes* and *Nummulites laevigatus* together, and this proves the Lutetian age of the formation. For brackish and marine molluscs see (SZŐTS 1956. p. 24.).

Biozonation: NP 14 (BÁLDI – BEKE 1984, BÁLDI – BEKE and KECSKEMÉTI 1983), *Nummulites laevigatus* assemblage zone (KECSKEMÉTI 1983).

References to L. S. I.:

Couches à *Alveolina oblonga* p. 52.
Couches à *Cerithium baconicum* p. 136.
Calcaire *Alveolines et Miliolidés* p. 53.
Marne à *Miliolidés de Urkut* p. 524. (partly)

2. Szőc Limestone Formation

Sublittoral limestone with abundant larger foraminifera ("Hauptnummulitenkalk"). Its greatast thickness is 200 meters (DUDICH 1977, DUDICH and GIDAI 1980).

Nannoplankton: It is extremely rare because of the unfavorable facies, occurs only in the marly beds. In the lower portions of the formation occurs *Rhabdosphaera inflata* (NP 14) together with *Nummulites laevigatus*, in higher portions *Reticulofenestra placomorpha* (=*R. umbilica*) and *Pemma papillatum* (NP 16). Zone markers for NP 15 are missing, but the continuous sedimentation and the evolutionary trends having been observed in some placoliths (*Reticulofenestra placomorpha, R. bisecta*) marks the presence of this zone (BÁLDI – BEKE 1983, 1984).

Other fossils: Mainly larger foraminifera, *Nummulites laevigatus, Assilina spira, Nummulites perforatus* and *N. millecaput* (from the base to top) occur as dominant forms (KOPEK, KECSKEMÉTI and DUDICH 1965). KECSKEMÉTI (1983 and in BÁLDI – BEKE and KECSKEMÉTI 1983) placed the Szőc Formation within his new *Nummulites* assamblage-zones (from the base): *N. laevigatus* zone (upper part), *N. obesus* and *N. baconicus* zone, *N. lorioli* zone, *N. perforatus* zone and *N. millecaput* zone (lower part).

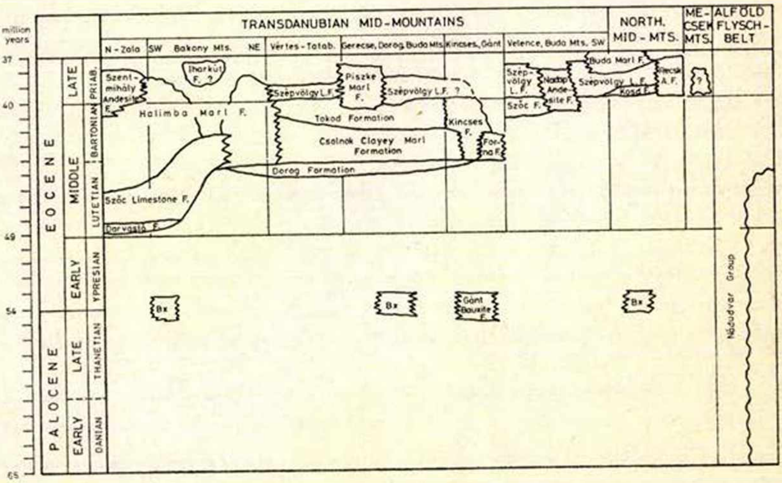

Fig. 4. Paleocene – Eocene formations of Hungary.

Biozonation: NP 14–15–16 (lower part) and the above mentioned *Nummulites* zones (KECSKEMÉTI 1983).

References to L. S. I.:

'Hauptnummulitenkalk" p. 241.
Couches à *Assilina spira* p. 69.
Calcaire à *Alvéolines et Miliolidés* p. 53. (partly)
Couches à *Nummulites laevigatus* p. 368.
Couches à *Nummulites millecaput* p. 370.
Couches à *Nummulites perforatus* p. 371.

3. Halimba Marl formation*

A) Halimba Formation in the SW part of the Bakony Mts

A marly series of pelagic origin in the southwestern Bakony. Its maximal thickness is 250 meters. It is glauconitic in its lower portion, (this was separated earlier as Csabrendek Formation), in the higher portions the tuffaceus intercalations are more frequent (DUDICH 1977, DUDICH and GIDAI 1980).

Nannoplankton: abundant, mainly placoliths, also *Discoasters* and *Sphenoliths* are rather common. Pentaliths, discoliths are extremly rare: this assamblage is an "oceanic type" (BÁLDI–BEKE 1984). In the Uppermost Middle Eocene the coccoliths are overcalcified ("robust *Zygolithus dubius* horizon' BÁLDI–BEKE 1971, BROKÉS 1978).

Zone markers for NP 16 to NP 19. *Reticulofenestra placomorpha, Pemma papillatum, Lanternithus minutus* from the base of the formation, NP 16. The NP 16/17 boundary is marked by the last occurence of *Chiasmolithus solitus* and *Sphenolithus furcatolithoides*, and by the first occurence of *Sphenolithus predistentus*. In the Upper Eocene portion *Chiasmolithus oamaruensis* (NP 18) and *Isthmolithus recurvus* (NP 19) make their first occurence (BÁLDI–BEKE 1971, 1983, 1984, BROKÉS 1978).

Other fossils: Larger foraminifera are poor, *Nummulites millecaput* (in the lower portion of the formation), *Discocyclina* and *Nummulites fabianii* (in the upper portion) (KECSKEMÉTI 1980, 1983).

The Upper Eocene larger foraminifera were transported from the littoral region to the deeper part of the basin by turbiditic currents in the uppermost part of the formation (BERNHARDT et al. 1985). Planktonic foraminifera are common: *Globorotalia lehneri, Truncorotaloides rohri, Globigerapsis mexicana* (TOUMARKINE 1971).

Biozonation: NP 16 to 19, *Globorotalia lehneri* to *Globigerinatheca semiinvoluta* zones of BOLLI (TOUMARKINE 1971, and K. HORVÁTH–KOLLÁNYI in BERNHARDT et al. 1985. and personal communication), *Nummulites millecaput* to *Nummulites fabianii* zones (KECSKEMÉTI 1983).

* The term "Halimba Formation" is required for the bauxites of the Bakony Mts. In consequence of this, the name is to be changed into "Padrag Formation (resolution of the Hungarian National Comittee of Stratigraphy).

References to L. S. I.:

Marne glauconieuse et tufacée de Bakony p. 77.

B) Halimba Formation in the northeastern part of the Bakony Mts (=earlier named as Mór Formation).

Silts and marls with calcareous sandstone and limestone-intercalations in the Northeastern Bakony (see DUDICH and GIDAI 1980, with the earlier used other names for the Formation: marl with foraminifera and molluscs, Porva marl, marl with *Hantkenina*, marl with *Vasconella*, Mór Formation).

Nannoplankton: common placoliths, holococcoliths, pentaliths, ecologically near-shore-type assemblage, but less typical than that of the Dorog Formation in the lower position. The facies upwards became more pelagic and the nannoplankton assemblage is without the typical near-shore forms (BÁLDI–BEKE 1984). Zone markers for NP 16 to NP 19 as listed from the Halimba Formation (BÁLDI–BEKE 1971, 1983, 1984, BROKÉS 1978). In the lowermost portion of the formation some specimens of *Reticulofenestra tokodensis* appear marking the presence of the same horizon in the same position, above the coal seams, as in the Dorog Formation (BÁLDI–BEKE 1982, 1983, 1984). In the latest Lutetian the coccoliths are commonly represented by overcalcified forms: robust *Zygolithus dubius* and *Discoaster* horizon by BÁLDI–BEKE 1971.

Other fossils: smaller foraminifera: common planktonic and benthonic forms, zone markers for *Globorotalia lehneri*, *Orbulinoides beckmanni*, *Truncorotaloides rohri* and *Globigerinatheca semiinvoluta* zones of BOLLI (SOLDAINI 1970, SAMUEL 1972, HORVÁTH–KOLLÁNYI 1983). HANTKEN 1875: lower portion of the *Clavulina szabói* beds – partly. Larger foraminifera: *Nummulites perforatus*, *N. striatus*, *N. millecaput*, *N. fabianii* (KECSKEMÉTI 1980, 1983, BÁLDI–BEKE and KECSKEMÉTI 1983), "Biarritzian" *Alveolina* species: *A. elongata*, *A. fusiformis*, *A. fragilis* (JÁMBOR–KNESS 1981). Rich mollusc assemblages (SZŐTS 1956, KECSKEMÉTI–KÖRMENDY 1980, KECSKEMÉTI–KÖRMENDY and M. MÉSZÁROS 1980), for the less typical shallow marine facies, see SZŐTS 1953 and STRAUSZ 1963.

Biozonation: NP 16 to NP 19 nannoplankton-zones, *Globorotalia lehneri* to *Globigerinatheca semiinvoluta* planktonic foraminifera zones (SOLDAINI 1970, SAMUEL 1972, HORVÁTH–KOLLÁNYI 1983), *Nummulites perforatus*, *N. millecaput* and *N. fabianii* zones (KECSKEMÉTI 1983).

References to L. S. I.:

Marne de Porva p. 419.

4. Dorog Formation (=earlier named as Tatabánya Formation)

Transgressive series with variegated clay in its lower portion, clays, marls and freshwater limestones with productive coal seams in the upper portion. DUDICH (1977) and DUDICH and GIDAI (1980) separated previously the Kisgyón Formation for the NE Bakony (Dudar, Balinka) and the Tatabánya Formation for the NE Transdanubia (Tatabánya, Pusztavám, Dorog). The name "Dorog Formation" was used by HANTKEN (1871, 1878) for the series with Eocene coal seams.

Nannoplankton: occurs only scattered. The zone markers for NP 16 were found even in the variegated clays: *Reticulofenestra placomorpha*, *Reticulofenestra bisecta* in their typical forms, from boreholes of both subareas (BÁLDI – BEKE 1983, 1984), and *Reticulofenestra placomorpha*, *Pemma papillatum*, *Lanternithus minutus* from the marly intercalations between the coal seams (BÁLDI – BEKE 1971, 1983, 1984).

The Dorog Formation is overlain by marine marls (Halimba and Csolnok Formations). Near to this boundary, mainly above the coal seams, occurs the *Reticulofenestra tokodensis*-horizon with the endemic, brackish nannoplankton species *R. tokodensis* (BÁLDI – BEKE 1982), and zone markers for NP 16 (BÁLDI – BEKE 1982, 1983, 1984).

Other fossils: palynomorphs (RÁKOSI 1973), freshwater and brackish water molluscs (SZŐTS 1956, KECSKEMÉTI – KÖRMENDY 1972).

Biozonation: NP 16 based on nannoplankton, local palynological zonation (RÁKOSI 1972, 1979), *Globorotalia lehneri* zone for the upper portion (HORVÁTH – KOLLÁNYI 1983).

References to L. S. I.:

Formation lignitifère de Dorog p. 185.
Formation lignitifère de Dudar – Balinka p. 188. for the so-called Kisgyón Formation
Argile bigarrée, calcaire d'eau douce Transdanubia NE p. 508.

5. Csolnok Formation (=earlier named as Dorog Formation)

Silty, clayey marls with rich sublittoral faunal assemblages of molluscs and foraminifera. Its thickness is 20 – 80 meters (DUDICH and GIDAI 1980, GIDAI 1972). It occurs in the northeastern part of Transdanubia.

Nannoplankton: rich nannoplankton assemblages in nearshore facies with common placoliths, pentaliths, discoliths, rhabdoliths, holococcoliths and *Neococcolithes dubius*, rare *Discoasters* and *Sphenoliths* (BÁLDI – BEKE 1984). All the zone markers for NP 16 are present: common *Reticulofenestra placomorpha* and *R. bisecta*, *Lanternithus minutus*, *Pemma papillatum*, *Chiasmolithus solitus*, *Sphenolithus furcatolithoides* (BÁLDI – BEKE 1983, 1984). Mostly the lowermost portion of the formation represents the *Reticulofenestra tokodensis*-horizon with the common occurence of *R. tokodensis* and zone markers for NP 16 (see in the Tatabánya and Mór Formations too, BÁLDI – BEKE 1982, 1983, 1984).

Other fossils: larger foraminifera: *Operculina div. sp.* and *Nummulites subplanulatus*, *N. globulus*, *N. anomalus*, *N. subramondi* (JÁMBOR – KNESS 1972), *N. subplanulatus*, *N. perforatus* (KECSKEMÉTI and VAŇOVÁ 1972). Smaller foraminifera (HORVÁTH – KOLLÁNYI 1983), sporomorphs (RÁKOSI 1973), molluscs (SZŐTS 1956, KECSKEMÉTI – KÖRMENDY 1972, STRAUSZ 1974).

Biozonation: NP 16, *Globorotalia lehneri* zone in its lower portion, *Truncorotaloides rohri* – *Orbulinoides beckmanni* zone in its upper portion (HORVÁTH–KOLLÁNYI 1983), *Nummulites subplanulatus* zone for the Cuisian by JÁMBOR–KNESS (1972), *Nummulites perforatus* assemblage zone for the Upper Lutetian (KECSKEMÉTI and VAŇOVÁ 1972).

References to L. S. I.:

Marne argileuse a *Operculines* p. 384.
Couches à *Nummulites subplanulatus* p. 374. with earlier synonimes:

HANTKEN 1871: Étage des Mollusques inférieur,

ROZLOZSNIK, SCHRÉTER and TELEGDI–ROTH 1922: Marne à *Operculines*,

SZŐTS 1956: Marne argileuse a Foraminifères et Mollusques,
KOPEK, KECSKEMÉTI and DUDICH 1965: Horizon No. VIII. a *N. subplanulatus*

6. Tokod Formation

Highly variable lithofacies, mostly sands, calcareous sandstones, limestones. Its lower portion is more calcareous, this regressive series is closed with coal seams ("Forna seams") the upper portion is more sandy and the fauna marks increasing salinity in the "striatus beds" (MUNTYÁN 1984 manuscript, DUDICH and GIDAI 1980).

Nannoplankton: occurs only in some lithologically and ecologically favourable beds, poor assemblages of NP 16 were found in the lowermost portion of the formation and NP 17 forms in its upper portion (BÁLDI–BEKE 1983, 1984).

Other fossils: larger foraminifera, *Nummulites perforatus*, common *N. striatus;* molluscs: SZŐTS 1956, KECSKEMÉTI–KÖRMENDY 1972.

Biozonation: NP 16 (partly) and NP 17. *Nummulites perforatus*, *N. millecaput* zones, the lowermost part of the *N. fabianii* zone is uncertain (MUNTYÁN 1984). *Truncorotaloides rohri* and *Orbulinoides beckmanni* planktonic foraminifera zones (HORVÁTH–KOLLÁNYI 1983).

References to L. S. I.:

Grès de Tokod p. 501.
Couches à *Nummulites striatus* de Bakony p. 373.
Couches à Mollusques et à *Nummulites striatus* de Dorog p. 186.
Couches de Forna p. 211.
Gisement de lignite de Forna p. 212.
Calcaire et marne a *Miliolidés* de Gánt p. 217.

7. Szépvölgy Limestone Formation (=earlier named as Nagysáp Formation)

Sublittoral limestones with marly and sandy intercalations (DUDICH and GIDAI 1980). It is underlain by the beds of the Tokod Formation or it lies unconformly on older rocks. It occurs not only in Transdanubia but in

Northeastern Hungary too. A more marly series with coal seams on its base is known near to Kósd (GIDAI 1978).

Nannoplankton: because of the unfavourable facies is extremely poor, however in some marly beds mainly placoliths and *Isthmolithus recurvus* occur (in GIDAI 1978, BÁLDI–BEKE 1984).

Other fossils: abundant larger foraminifera (HANTKEN 1871, VITÁLIS–ZILAHY 1967, JÁMBOR–KNESS 1972): *Nummulites fabianii* and *Discocyclinidae*, abundant calcareous algae *(Lithothamnium)*, few molluscs (KECSKEMÉTI–KÖRMENDY 1972), smaller foraminifera.

Biozonation: NP 18 and NP 19. The formation belongs to the Lower Priabonian (based on the larger foraminifera fauna), and perhaps to the uppermost Middle Eocene in some places (Urhida). The *Globigerinatheca semiinvoluta* zone (HORVÁTH–KOLLÁNYI 1983) has been proved.

References ti L. S. I.:

Calcaire à *Nummulites – Orthophragmines* p. 365.
Couches à *Nummulites fabianii* p. 367.
Calcaire marneux à *Nummulites böckhi* p. 367.

8. Piszke Marl Formation

Pelagic marly series, which is known from a small area near Lábatlan (Northern Gerecse Mountains near to the Danube, HANTKEN 1871, VOGL 1910, GIDAI 1968, BÁLDI–BEKE 1984). It is underlain by Middle Eocene marly beds with *Nummulites striatus* as it has been proved in borehole profiles (GIDAI 1968).

Nannoplankton: The zone markers for NP 18 and 19 are common; *Chiasmolithus oamaruensis, Isthmolithus recurvus* and *Orthozygus aureus* occur together with *Discoaster barbadiensis* and *D. saipanensis* (BÁLDI–BEKE 1984 and in GIDAI 1968).

Other fossils: smaller foraminifera (HANTKEN 1871), *Bryozoa*, molluscs (VOGL 1910, SZŐTS 1956).

Biozonation: NP 18 and 19, *Globorotalia cerroazulensis* zone (HORVÁTH–KOLLÁNYI 1983).

References to L. S. I.:

Marne de Piszke p. 412.
Aleurite calcaire à Foraminifères de Nyergesujfalu p. 376.

9. Iharkut Formation

Conglomerates, sands with few marly beds (DUDICH 1977, DUDICH and GIDAI 1980, MÉSZÁROS 1980).

Nannoplankton: It occurs only in the marly beds, species from the NP 18 and 19 zones together with reworked Cretaceous forms (BÁLDI–BEKE 1983, 1984).

Other fossils: Nummulites is common in the conglomerate beds, *Nummulites perforatus* occurs in the pebbles from the underlying Szőc Limestone Formation. Few molluscs were found in marly clay, not studied yet.

Biozonation: Highly uncertain. The locally rich Late Eocene nannoplankton assemblage may be most probably reworked. The age of the formation may be Oligocene, because of the lithostratigraphical position. Among the several underlying formations the youngest one is the Szőc Limestone (Middle Eocene). The Iharkut Formation is overlain mainly by the Late Oligocene Csatka Formation.
No references in the L. S. I.

Oligocene Formations

1. Buda Marl Formation

The formation extends from the Buda and Pilis Mountains up to the Bükk-region, toward a northeastern direction. The characteristic rock-types are marl and calcareous marl. Its upper portion contains an increased amount of terrigenous material. This upper portion consists usually of clayey marl with allodapic limestone interbeddings. The formation represents a transgression from the deep – sublittoral until the bathyal environments.

Nannoplankton: The nannoplankton-content of the lower, more calcareous member is usually poorer, while that of the upper, more clayey member is more rich. The cosmopolitan placoliths are rather common (*Reticulofenestra bisecta, Reticulofenestra callida*), the pentaliths, discoasterids, sphenoliths appear only rarely. The holococcoliths show usually a great abundance, mainly the species *Lanternithus minutus, Zygrhablithus bijugatus* and *Isthmolithus recurvus*. The ratio of the tropical elements in the nannofloras is less, comparing to the Middle-Eocene nannofloras (Báldi–Beke 1972, 1977, 1984, Nagymarosy in Báldi et al., 1984).

Other fossils: planktonic foraminifera (see Sztrákos 1974, 1978, Horváth in Báldi et al., 1984); ostracoda (Monostori 1985a, 1985b, 1986a, 1986b); the benthic foraminiferas were described by Hantken (1866, 1873); Báldi (1983) dealt with the *Propeamussium* mollusc genus.

Biozonation: The age of the nannoplankton was determined by Báldi–Beke and Nagymarosy: zone NP 19–20 (see the titles above). These two zones are not to be easily separated, because the biostratigraphic event – first appearance of the species *Sphenolithus pseudoradians* – defining the base of the zone NP 20 is a rather heterochronous level. The base of NP 19 is well defined by the first appearance of the *Isthmolithus recurvus*, which is rather common in this formation. The boundary between the zones NP 20 and 21, i. e. the Eocene-Oligocene boundary, can be fixed near to the uppermost calcareous marl-intercalations of the Buda Marl. This important horizon is hardly recognizable, because the tropical index species *Discoaster saipanensis* and *Discoaster barbadiensis* occur only rarely and sporadically in this formation. Also the permanent reworking of the Middle Eocene nannofossils makes the determination of this horizon difficult (Nagymarosy et al., 1986). Kecskeméti et al., 1985. put the Buda Marl into the *Nummulites fabianii* larger-foraminifera zone, whose upper boun-

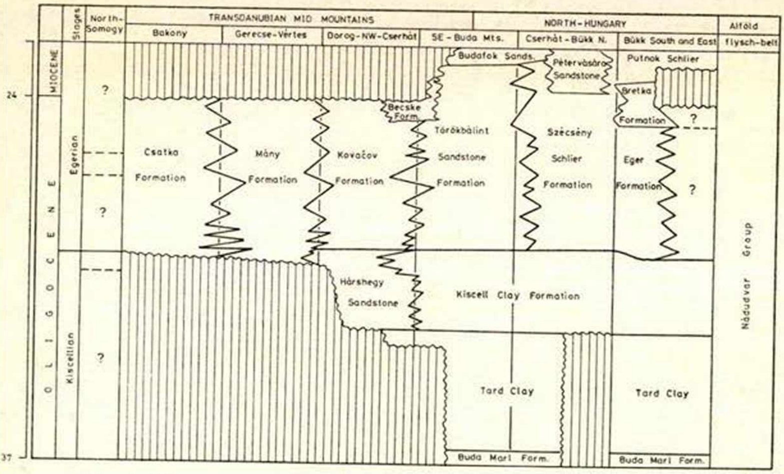

Fig. 5. Oligocene – Lower Miocene formations of Hungary.

dary can be located in the upper portion of the formation. HORVÁTH (1983, in BÁLDI et al., 1984) described planktonic foraminiferas from the marl belonging to the P 17 zone of BLOW, while SZTRÁKOS (1974, 1978) described the Carpathian-Pannonian regional *Globigerina officinalis* zone.

References.

Marne à *Bryozoaires* L. S. I. p. 113
Marne de Buda L. S. I. p. 116
Budai Márga, BÁLDI 1983. p. 19
Buda Marl, BÁLDI 1986. p. 9

2. Tard Clay Formation

This formation – whose typical outcrops have a characteristic "black-shale-like" appearance – consists of different rock-types, i.e. microlaminated clays, silts, non-microlaminated clayey marls and sandstones. It lays conformly on the Buda Marl. The boundary of these two formations can be drawn either at the uppermost calcareous bed or at the lowermost anoxic laminite-bed. The areal occurence of the Tard Clay is similar to that of the Buda Marl.

Nannoplankton: The lower member of the formation contains low-diversity, high-aboundance nannoplankton assemblages. *Reticulofenestra bisecta, Reticulofenestra callida* and *Reticulofenestra hesslandii* are common, while the *Cyclococcolithus formosus* and *Reticulofenestra placomorpha* index-species are rare. (A deal of these two latter fossils may be reworked from the Middle-Eocene rocks.) The acme of *Ericsonia subdisticha* – characteristic for the zone NP 21 – is well recognizable. The cold-water holococcoliths *Zygrhablithus bijugatus, Lanternithus minutus, Isthmolithus recurvus* are especially very abundant.

In the interval of the boundary between the lower and upper members of the Tard Clay the appearance of mono- and duospecific nannofloras was observed due to the slight decrease in the salinity of the surface-water. These mono- or duospecific assemblages consist of big masses of one or two species, while the other species with a less tolerancy appear only sporadically. The characteristic forms of these assemblages are the *Orthozygus aureus, Discolithina latoculata, Transversopontis obliquipons, Reticulofenestra ornata, Reticulofenestra lockeri*, etc. (see NAGYMAROSY 1983a). The upper member of the formation is usually free of fossils, except some short blooms of the above mentioned high-tolerancy forms.

Other fossils: Benthic foraminiferas (their detailed investigation has not be completed yet); planktonic foraminiferas (SZTRÁKOS 1974, 1978, HORVÁTH 1983 and in BÁLDI et al,, 1984); ostracods (MONOSTORI 1985a, 1985b, 1986a, 1986b); the rare and badly preserved endemic brackish water *Cardium lipoldi* mollusc-fauna of the Tard Clay was described by BÁLDI (1983, 1986).

Biozonation: The lower member of the Tard Clay corresponds to the zones NP 21 – 22, while its upper member to NP 23 (BÁLDI – BEKE 1977, 1984, NAGYMAROSY 1983b and in BÁLDI et al., 1984). The NP 21/22 zone – boundary cannot be easily drawn because of the reworking of the index-fossils from the older Paleogene beds. The base of the zone NP 23 is indicated by the sudden impoverishing or full extinction of *Reticulofenestra placomorpha* and by the sudden increase in the abundancy of *Reticulofenestra lockeri*. The zone-boundary defining species *Sphenolithus distentus* is extremely rare. In the upper part of the NP 23 zone few specimens of "early" *Helicopontosphaera recta* have been observed.

The endemic "Paratethys-dweller" nannoplankton species occur in the same level as the endemic mollusc fauna does (see BÁLDI 1983). These are: *Reticulofenestra ornata* MÜLLER, and *Transversopontis fibula* GHETA (= *Transversopontis pax* STRADNER = *Zygodiscus vialovi* ANDREYEVA – GRIGOROVICH), whose occurence can be traced from the Bavarian molasse up to Usbekistan. This horizon can be put onto the lower boundary of the zone NP 23. SZTRÁKOS (1974) correlated the lower member of the Tard Clay with the *Globigerina postcretacea* – zone of SAMUEL and SALAJ (1968). HORVÁTH (see the references above) described planktonic foraminifera assemblages corresponding to BLOW's P 18 and P 19/20 zones.

References

Couches de Tard L. S. I. p. 486
Tardi Agyag, BÁLDI 1983 p. 22
Tard Clay, BÁLDI 1986 p. 11

3. Hárshegy Sandstone Formation

The Hárshegy Sandstone is the basal formation for the transgressional cycle of the Kiscell Clay. It has been formed in the zone extending west to the Buda-line, between the Cserhát and the Buda Mountains.

The different rock-types of the Hárshegy Sandstone, – conglomerates, coarse and fine grained sandstones – have formed in the wave-activity belt of the ancient sea. The other rock-variations, as silt, clayey sand, fire-clay beds were deposited in nearshore lagoons. The huge body of the Hárshegy Sandstone underwent a strong silification after the sedimentation along the Buda-line, and the silicifying solutions destroyed the greatest part of its fossil-content.

Nannoplankton: The depositional and diagenetic environments of the Hárshegy Sandstone did not favour to the fossilization of nannofossils. Among the few data we have to mention the impoverished placolith assemblages with *Cyclicargolithus abisectus* described by Báldi–Beke (in Báldi et al., 1976). Similar nannoplankton assemblages were found by Nagymarosy in the Cserhát Mountains (Romhány-block): low-diversity placoliths with *Coccolithus rupeliensis* Müller and rare *Helicopontosphaera recta* Haq.

Other fossils: The rare foraminifera faunas were described by Gellai (1966, 1973) and Horváth (in Báldi et al., 1976). Kecskeméti dealt with the larger foraminiferas, i. e. with *Lepidocyclinas* and *Nummulites* (in Báldi et al. 1976). The mollusc faunas were determined by Báldi (in Báldi et al. 1976, Báldi 1983).

Biozonation: The nannoplankton of the Hárshegy Sandstone may not be older than the upper part of NP 23. The presence of *Cyclicargolithus abisectus* and *Helicopontosphaera recta* suggest an age of NP 24. The larger foraminiferas and molluscs prove a Late Kiscellian age too, in concordance with the nannoplankton.

References:

Grès de Hárshegy L. S. I. p. 235
Hárshegyi Homokkő, Báldi 1983 p. 33
Hárshegy Sandstone, Báldi 1986 p. 32
Complexe lignitifère d'Esztergom L. S. I. p. 200
Gisement lignitifère de Szápár L. S. I. p. 472

4. Kiscell Clay

A rather uniform formation consisting of calcareous clay and clayey marl. In its lower member there is a typical alternation of clay- and sandstone-beds. The depositional depth of the Kiscell Clay was presumably 400–500 m. The formation extends from the southern foredeep of the Vértes and Gerecse Mountains through South Slovakia up to the Northern Bükk Mountains. West to the Buda-line it is overlying the transgressive Hárshegy Sandstone with a thickness of some dozen meters. East to the Buda-line it is overlying the euxinic Tard Clay. The thickness of the Kiscell Clay may be as much as 800 or even 1000 meters in this area.

Nannoplankton: The Kiscell Clay contains a rich, hemipelagic nannoflora. Its dominating forms are the placoliths (*Reticulofenestra lockeri*, *Reticulofenestra hesslandii*, *Coccolithus pelagicus*, *Cyclicargolithus abisectus*, *Cyclicargolithus floridanus)*, but together with them also helicosphaerids *Helicopontosphaera bramlettei, Helicopontosphaera euphratis)*, discoliths *(Discolithina multipora, Transversopontis pygmaea)* and *Zygrhablithus bijugatus* occur. Some tropical nannoflora elements, as discoasterids are totally lacking, but the sphenoliths are more common. BÁLDI–BEKE (1977) described a rather fixed horizon from the lower part of the formation with common *Sphenolithus distentus, Sphenolithus ciperoensis* and *Sphenolithus predistentus*. In the thick-bedded, hardly stratified clay also microlaminated, anoxic intercalations occur, which contain rich marine nannofloras – in contrary of the Tard Clay –. However, also these diverse nannofloras may be mixed with the blooms of one-one species (NAGYMAROSY 1983).

Other fossils: Almost 500 foraminifera species were described from this formation in the last hundred years (HANTKEN 1975, MAJZON 1966, SZTRÁKOS 1978, HORVÁTH 1983). The ostracods were investigated by MONOSTORI (1982, 1985a, 1985b, 1986a, 1986b). Detailed evaluation of the mollusc fauna was made by BÁLDI (1986).

Biozonation: The depositional interval of the Kiscell Clay corresponds to the lower part of the NP 24 zone. HORVÁTH (1983) put the formation in the *Globorotalia opima opima* zone on the basis of planktonic foraminiferas. According to SZTRÁKOS (1978) it belongs to to the *Globorotalia munda* endemic taxon-interval zone. MAJZON (1942, 1961) divided the Kiscell Clay in North Hungary into four foraminifera-ecozones, but HORVÁTH and SZTRÁKOS found only one stratigraphically fixed level among them. A radiometric measurement on the glauconite of the Kiscell Clay resulted in an age of 33,5 million years (BÁLDI et al. 1975).

References:

Argile de Kiscell L. S. I. p. 271
Kiscelli Agyag, BÁLDI 1983. p. 51
Kiscell Clay, BÁLDI 1986. p. 16

5. Csatka Formation

It consists of alternating fresh-water coarse-grained clastics and variegated clays. Its type occurence is in the Bakony and Vértes Mountains (see KORPÁS 1981).

Nannoplankton: Though this formation might not contain any autochtonous nannoplankton due to its depositional environment, BROKÉS (1978) described impoverished assemblages from grey, fluviatile clays. These assemblages may contain rare specimens of *Sphenolithus distentus, Sphenolithus ciperoensis* and *Cyclicargolithus abisectus* too.

Other fossils: The fresh-water mollusc fauna was investigated by BÁLDI (1973).

Biozonation: Concerning the above mentioned index-species, the Csatka Formation may belong to the Egerian stage, to the nannoplankton zones NP 24–25.

References:

Csatkai (=Móri) Formáció, BÁLDI 1983. p. 92
Csatka (=Mór) Gravels, BÁLDI 1986. p. 39.

6. Mány Formation

Alternation of brackish-water and fresh-water clastics with that of marine origin. Occurence: in the triangle among the Vértes-Gerecse and Buda Mountains.

Nannoplankton: The marine intercalations contain persistent, cosmopolitan forms: *Coccolithus pelagicus, Cyclicargolithus floridanus, Helicopontosphaera euphratis, Reticulofenestra bisecta*, etc. The index fossils are very rare. The locally very abundant *Discolithina latelliptica* is a typical element of these nannofloras. The greatest deal of the nannoplankton assemblages consists of specimens, which have been reworked from the older Paleogene and Cretaceous beds (see BROKÉS 1978, BÁLDI–BEKE 1977, 1984).

Other fossils: For the typical brackish-water mollusc fauna see BÁLDI 1973.

Biozonation: The age of the formation is NP 24–25. The two zones can not be separated from each other because of the lacking of the index species. Concerning the nannoplankton assemblages of this formation one can determine an age not younger than Early Egerian, so the formation does not overlap the Paleogene/Neogene boundary.

References:

Couches à *Cyrènes* L. S. I. p. 168
Mányi Formáció, BÁLDI 1983. p. 92
Mány Sands, BÁLDI 1986. p. 39

7. Kováčov Formation

Alternating beds of marine and brackish-water sands and sandy silts (BÁLDI 1973). The formation occurs around Esztergom and at the western margin of the Cserhát Mountains. HÁMOR (1985) described its upper, regressive portion as Becske Formation.

Nannoplankton: Poorly studied. The few data show a concordance with the nannoplankton of the Mány Formation (BÁLDI–BEKE 1977, 1984).

Other fossils: foraminiferas (HORVÁTH 1980); molluscs (BÁLDI 1973).

Biozonation: It belongs to the NP 24–25 nannoplankton zones without any more detailed division.

References:

Argile à *Helix* de Mohora L. S. I. p. 339
Kovačovi Formáció, BÁLDI 1983. p. 93
Kovačov Sands, BÁLDI 1986. p. 39

8. Törökbálint Sandstone

Nearshore and littoral sands and sandstones extending from the Buda Mountains through the Pilis up to the Cserhát. West to the Buda-line its upper portion contains some brackish-water interbeddings and it is cut by an erosional unconformity. East to the Buda-line it is conformly overlain by the Budafok Sand of Early Miocene age.

Nannoplankton: The cosmopolitan *(Coccolithus pelagicus, Reticulofenestra bisecta, Cyclicargolithus floridanus)* and the nearshore species *(Discolithina enormis, Discolithina latelliptica, Braarudosphaera bigelowi)* are common. In the uppermost part of the formation also *Helicopontosphaera carteri* appears.

Other fossils: foraminifera (Horváth 1980); molluscs (Báldi 1973).

Biozonation: The formation can be placed into the NP 24–25 nannoplankton zone. The Törökbálint Sandstone may overlap the Oligocene/Miocene boundary and extends into the NN 1 zone according to Báldi–Beke (see Budafok–2 borehole in Báldi et al. 1973).

References:

Sable à *Pectoncles* L. S. I. p. 403
Törökbálinti Formáció, Báldi 1983 p. 93
Törökbálint Sands, Báldi 1986.

9. Eger Formation

It lays conformly on the Kiscell Clay at the southern and eastern margin of the Bükk Mountains. Its typical rock-variant is the deep-sublittoral clayey marl, whose upward transition contains several silty and sandy intercalations. The stratigraphical column terminates in a brackish-water series. A characteristic variation of the Eger Formation is the Novaj Member consisting of clay, marl, limestone and glauconitic sandstone beds with larger foraminiferas.

Nannoplankton: The rich marine nannoplankton of the Eger Formation was described by Báldi–Beke (1975, Báldi–Beke et Báldi 1974, and in: Báldi et al. 1975). In addition to the abundant placoliths some sphenoliths *(Sphenolithus ciperoensis)* and helicosphaerids *(Helicopontosphaera carteri)* occur too. Typical elements of the nannofloras are the reworked specimens from Cretaceous and older Paleogene beds. The upper, brackishwater portion of the formation contains no nannofossils.

Other fossils: foraminiferas (Horváth 1980); larger foraminiferas (Báldi et al. 1961); molluscs (Báldi 1966, 1973, Báldi–Beke et Báldi 1974.

Biozonation: The Eger Molluscan Clay, the brackish-water overlying strata and the Novaj Member all belong uniformly to the upper part of zone NP 24 and to the lower part of zone NP 25. The formation does not overlap the Oligocene/Miocene boundary. Horváth (1980) determined it as belonging to the *Globorotalia opima opima* zone. Drooger (in Báldi et al. 1961) described the larger foraminifera species *Miogypsina septentrionalis* from the Novaj Member.

References:

Couches de Demjén(*Lepidocyclina* and *Heterostegina* bearing beds = Novaj Member)L. S. I. p. 176
Egri Formáció, BÁLDI 1983. p. 94
Eger Formation, BÁLDI 1986. p. 49

10. Szécsény Schlier

This 400–800 m thick neritic formation is located at the northern margin of the Cserhát, Mátra and Bükk Mountains. Its most typical rock-variation is the sandy-clayey silt. It lays conformly on the Kiscell Clay, and it is covered by Lower Miocene sandstones.

The Szécsény Schlier is very similar to the Putnok Schlier formation, also their depositional times show an overlap. However is has not been proved, that there would be any connection between the two rock bodies.

Nannoplankton: In contrary to its hemipelagic, pelitic character, the Szécsény Schlier is relatively poor in nannofossils. Its typical placoliths are *Coccolithus pelagicus*, *Cyclicargolithus floridanus*, *Reticulofenestra bisecta* (only in the deeper portion of the formation), *Cyclococcolithus leptoporus*(in the higher portion of the formation). Common elements of the nannofloras are *Helicopontosphaera carteri*, *Discolithina latelliptica*, *Sphenolithus moriformis*. The discoasteroids are rare, for example *Discoaster trinidadensis*, *Discoaster lidzii*, *Discoaster druggii* (see HORVÁTH et NAGYMAROSY 1979).

Other fossils: The foraminifera faunas consist mainly of agglutinated forms (see HORVÁTH 1972); the typical mollusc fauna of the schlier is comprehensively described by BÁLDI (1973).

Biozonation: The lower member of the formation belongs probably to the NP 24–25 zones, but this has been proved only in some isolated, point-like outcrops. NAGYMAROSY (in HORVÁTH and NAGYMAROSY 1979) described NN 1 and 2 nannofloras from the upper member of the formation. The uppermost strata of the Szécsény Schlier underlying the Ipolytarnóc Footprinted Sandstone contain the species *Sphenolithus belemnos* in a relatively great abundance, thus their age must be NN 3.

References:

Schlier à *Bathysiphon* L. S. I. p. 89
Parádi Slir, BÁLDI 1983. p. 98
Szécsényi Slir, BÁLDI 1986. p. 98
Szécsény Schlier, BÁLDI 1986. p. 43

11. Nádudvar Group

The flysch-belt extending at the northern margin of the Great Hungarian Plain is not well-studied from the point of view of nannoplankton stratigraphy. Some investigations were carried out from isolated drilling core-materials and a few assemblages have been described from the zones NP 18 to NP 25 (BÁLDI – BEKE et al. 1980). The sampling technique and the tectonized borehole profiles did not enable the continuous sampling and studying of the stratigraphic column.

References:

Formations „flyschoides" de Hajduszoboszló – Tóalmás – Alcsi L. S. I. p. 232

12. Paleogene beds in Buzsák and Táska

NP 22, 24 and 25 zone assemblages were found in the rocks from some boreholes of Buzsák and Táska, south to the lake Balaton. (BÁLDI – BEKE 1984). The paleogeographical and tectonical interpretation of these beds is very uncertain so far.

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This paper does not deal with those geological formations of North-Hungary, whose age is not fixed by the geological literature uniformly in the Paleogene. Some authors give for them an age of Late Oligocene, others prefer the Early Miocene age. This paper supports the opinion, that all the following formations have a Neogene age. According to our investigations, the age of the overlying strata of the Bretka Limestone is NN 1. Pétervására Sandstone is NN 1 – 2,
of the Budafok Sand is NN2,
of the Putnok Schlier is NN 1 – 3.

No nannoplankton investigation was carried out on the Felsőnyárád Formation.

The exact position of these formations in the chronostratigraphic scale and in the Standard Nannoplankton zonation must be determined by a comprehensive research program in the future.

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